(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Neil Holger White EKLUND et al.	Group Art Unit 3693 Confirmation No. 5187
Serial No. 10/781,804	Examiner Edward J. Baird
Filed: February 20, 2004	Attorney Docket 141121-4

For: SYSTEMS AND METHODS FOR MULTI-OBJECTIVE PORTFOLIO ANALYSIS USING DOMINANCE FILTERING

APPEAL BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

As required under § 41.37(a), this brief is filed within two months of the Notice of Appeal filed in this case on February 27, 2009, and is in furtherance of said Notice of Appeal.

Table of Contents

This Appeal Brief contains items under the following headings as required by 37 C.F.R. § 41.37 and M.P.E.P. § 1205.02:

I. REAL PARTY IN INTEREST

The real party in interest for this Appeal is:

General Electric Company by way of an Assignment recorded at Reel/Frame 015679/0182 on August 12, 2004.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in this Appeal.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 15 Claims pending in application.

B. Current Status of Claims

1. Claims canceled: 3-5, 8-10, 14, 15, 21, 25 and 26.
2. Claims withdrawn from consideration but not canceled: None.
3. Claims pending: 1, 2, 6, 7, 11-13, 16-20 and 22-24.
4. Claims allowed: None.
5. Claims rejected: 1, 2, 6, 7, 11-13, 16-20 and 22-24.

C. Claims On Appeal

The Claims on Appeal are Claims 1, 2, 6, 7, 11-13, 16-20 and 22-24.

IV. STATUS OF AMENDMENTS

In the Advisory Action dated February 13, 2009, the Examiner indicates that the Request for Reconsideration filed in response to the final Office action will not be entered for purposes of Appeal. The status of the amendments to the Claims prior to filing the Notice of Appeal is as follows:

A. Responsive to a non-final Office action dated April 30, 2008, Appellant amended Claims 1, 2, 6, 7, 11-13, 16-20 and 22-24, and canceled Claims 3-5, 8-10, 14, 15, 21, 25 and 26 on July 23, 2008.

B. Responsive to a final Office action dated December 1, 2008, Appellant filed a Request for Reconsideration on December 23, 2008.

C. Responsive to an Advisory Action dated February 13, 2009, Appellant timely filed a Notice of Appeal on February 27, 2009.

V. SUMMARY OF CLAIMED SUBJECT MATTER

By way of background, dominance filtering is a highly useful component of our approach to multi-objective portfolio optimization, as shown in *Figure 2* below. To explain, given a set of M vectors to be partitioned into dominated and non-dominated subsets, and given N objectives, the worst-case computational complexity of the typical partitioning process is $O(N M^2)$. For large M and $N > 2$, the time required to partition the set of M vectors grows rapidly. Also, since the Pareto Sorting Evolutionary Algorithm (PSEA) is dependent on its ability to repeatedly and rapidly differentiate between the dominated and non-dominated solutions, speed in dominance filtering directly impacts the computational performance of the PSEA. See *Paragraph [0166]*.

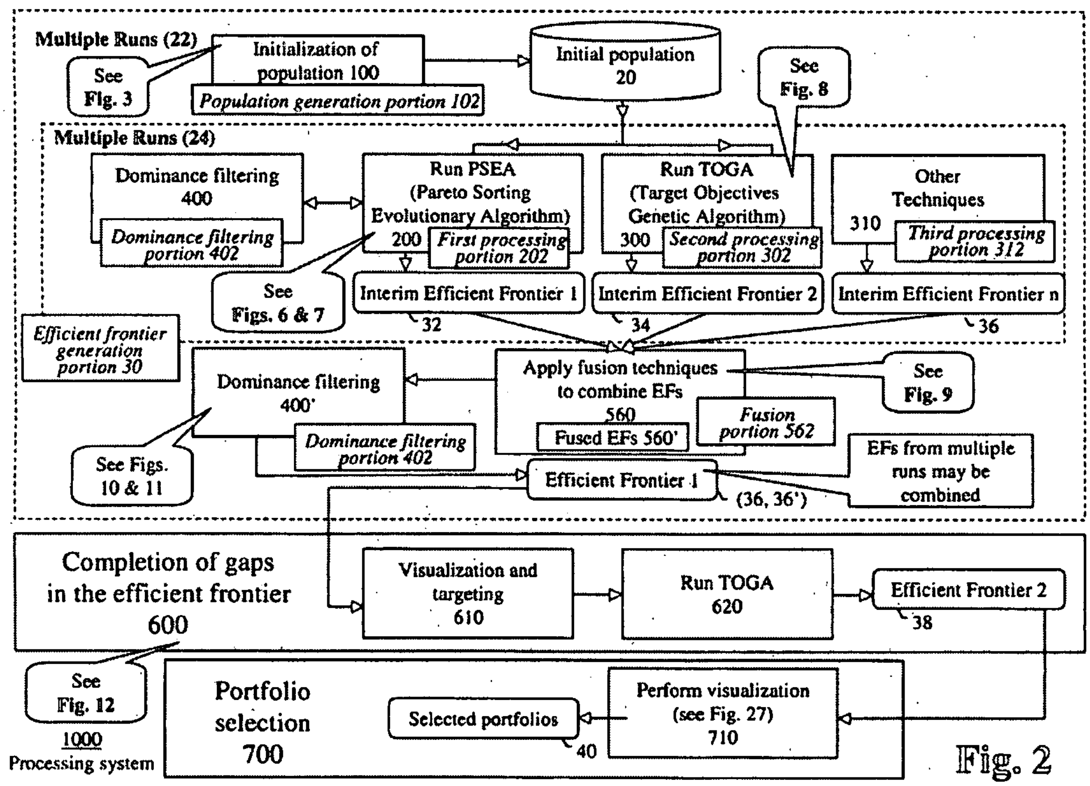

Fig. 2

Accordingly, in some embodiments of the invention, what might be characterized as a fast version of dominance filtering is disclosed below, i.e., an approach to dominance filtering that has been observed by the inventors to typically be faster than known approaches. This implementation, as provided by one aspect of the invention, relies on intelligently decomposing

the set of solutions to be partitioned, and working systematically on smaller subsets of the full set of solutions. Such a problem decomposition results in a significantly reduced problem complexity, since the cardinality (m), i.e., size, for these smaller sets is typically much smaller than the cardinality (size) of the entire solution set (m << M). See *Paragraph [00167]*.

However, while the use of a dominance filter is described herein in accordance with some embodiments of the invention, it is noted that the use of this specific implementation may not be needed, and that one novelty of the inventive systems and methods described herein is in the use of a dominance filter with performance better than the traditional $O(N\ M^2)$ for improving the on-line performance of a multi-objective search algorithm, and more specifically for portfolio optimization. Therefore, any so called fast dominance filter that may implement any from a diverse set of heuristics for improving on the traditional filter's computational performance without compromising on the quality of results may be utilized for the purposes of achieving performance improvements. See *Paragraph [0168]*.

Referring to *Figure 10* shown below, an explanation of the operation of the fast dominance filter is given in accordance with one embodiment of the invention. As shown, *Figure 10* includes four graphs representing the process or computational steps. As shown in *Figure 10*, the dominance filtering might be characterized as space decomposition based dominance filtering. Further, the dominance filtering process may be performed by a suitable dominance filtering processing portion 402. See *Paragraph [0169]*.

For purposes of illustration, the steps of *Figure 10* are shown in two dimensions. The two dimensions respectively represent two objectives. Accordingly, the goal of the fast dominance filtering process is the maximization of each of the two objectives, in this two-dimensional example. The process of *Figure 10* can and typically will be expanded to many more than two dimensions. Also, as illustrated in *Figure 2*, the fast dominance filtering process may be used in conjunction with the PSEA processing (step 200) and/or the related fusion processing (step 500), for example. See *Paragraph [0170]*.

As shown in *Figure 11* below, the process starts in step 400 and passes to step 410. In step 410, a set of initial data is provided. However, as used here, the term "initial data" means data initially used in the process of *Figure 11*. Accordingly, the initial data of step 410 may have been previously processed by any of a variety of other techniques, prior to the processing of *Figure 11*. See *Paragraph [0171]*.

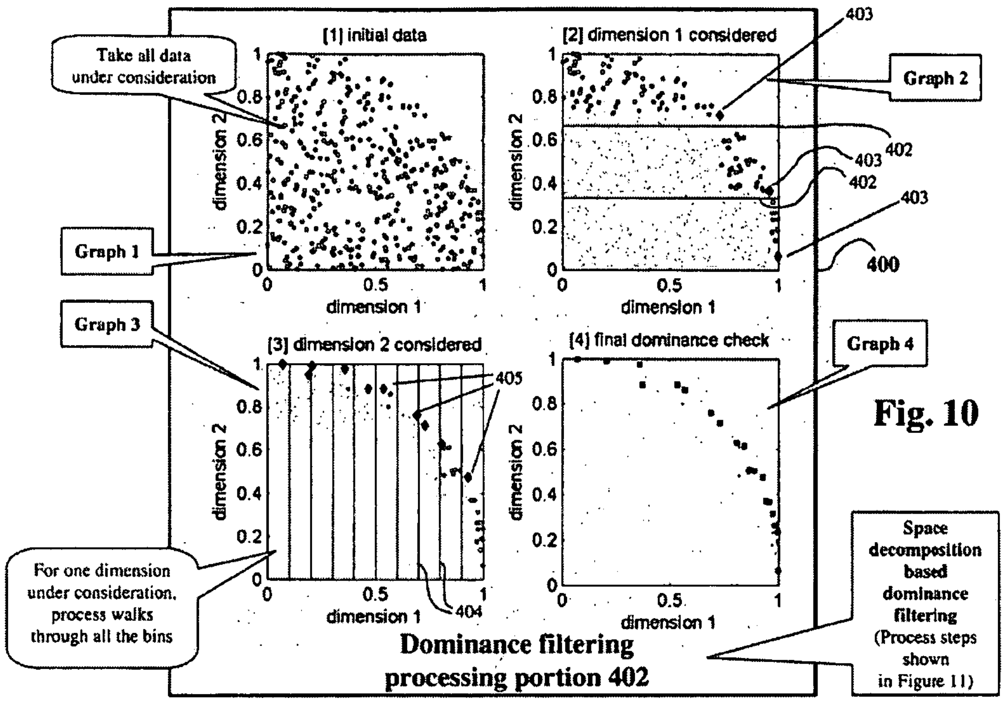
[1] initial data
Take all data under consideration
dimension 2
dimension 1
Graph 1
[2] dimension 1 considered
Graph 2
403
402
400
Graph 3
[3] dimension 2 considered
405
404
For one dimension under consideration, process walks through all the bins
[4] final dominance check
Graph 4
Space decomposition based dominance filtering (Process steps shown in Figure 11)
Dominance filtering processing portion 402

Fig. 10

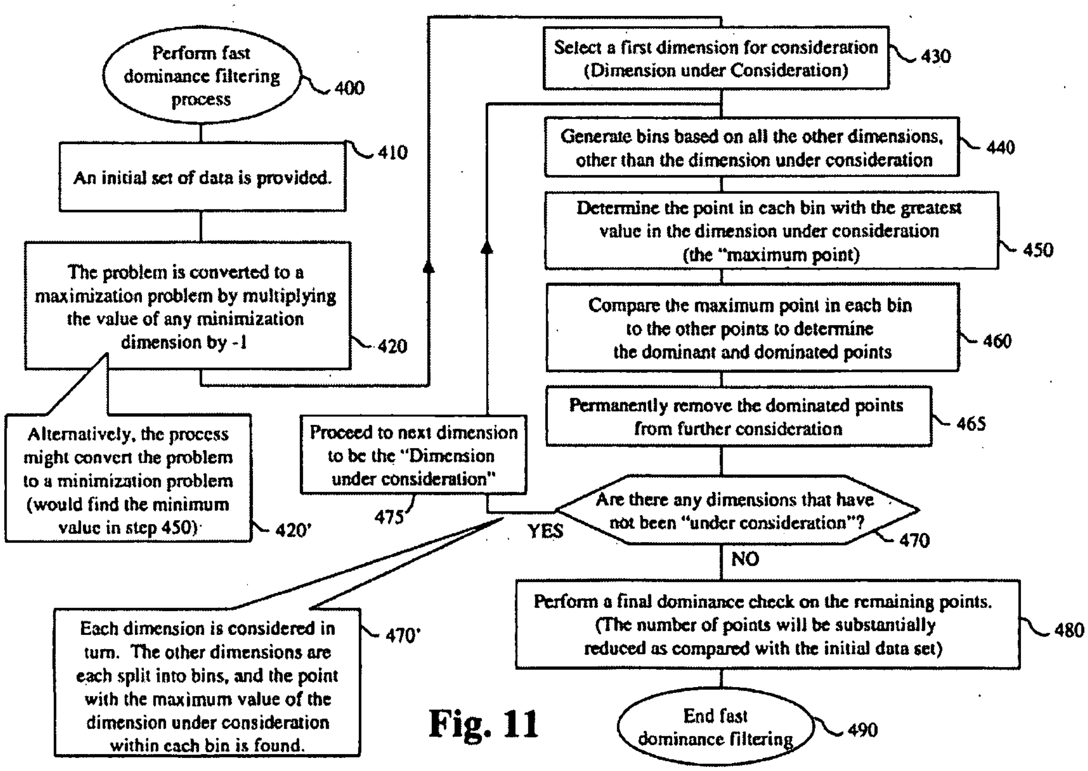
Perform fast dominance filtering process
400
An initial set of data is provided.
410
The problem is converted to a maximization problem by multiplying the value of any minimization dimension by -1
420
Alternatively, the process might convert the problem to a minimization problem (would find the minimum value in step 450)
420'
Select a first dimension for consideration (Dimension under Consideration)
430
Generate bins based on all the other dimensions, other than the dimension under consideration
440
Determine the point in each bin with the greatest value in the dimension under consideration (the "maximum point)
450
Compare the maximum point in each bin to the other points to determine the dominant and dominated points
460
Permanently remove the dominated points from further consideration
465
Proceed to next dimension to be the "Dimension under consideration"
475
Are there any dimensions that have not been "under consideration"?
470
YES
NO
Each dimension is considered in turn. The other dimensions are each split into bins, and the point with the maximum value of the dimension under consideration within each bin is found.
470'
Perform a final dominance check on the remaining points. (The number of points will be substantially reduced as compared with the initial data set)
480
End fast dominance filtering
490

Fig. 11

The initial set of data is also illustrated by graph 1 of *Figure 10*. After step 410 of *Figure 11*, the process passes to step 420. In step 420, the problem is converted to a maximization ("larger is better") problem by multiplying the value of any minimization ("smaller is better") dimension by -1. This step enforces uniformity in any sorting procedures and consequently saves computational time. However, the problem might alternatively have been converted to a minimization problem to achieve the same effect with no difference in the resulting Pareto optimal set. See *Paragraph [00172]*.

After step 420, the process passes to step 430. In step 430, a first dimension is selected for consideration. Accordingly, the considered dimension may be termed a "dimension under consideration." As shown in *Figure 10*, graph 2 illustrates consideration of dimension 1 and graph 3 illustrates consideration of dimension 2. See *Paragraph [00173]*.

After step 430, in which the dimension under consideration is selected, the process passes to step 440. In step 440, the process generates bins based on all the dimensions, other than the dimension under consideration. Thus, if dealing with a total of two dimensions, the binning will simply involve strips, as shown in Figure 10. In *Figure 10*, graph 2 shows the consideration of dimension 1 and includes splitting dimension 2 into a plurality of bins 402. On the other hand, graph 3 shows the consideration of dimension 2 and includes splitting dimension 1 into a plurality of bins 404. See *Paragraph [00174]*.

Alternatively, if dealing with a total of three dimensions, the binning will involve decomposing the space into rectangles based on all the dimensions, other than the dimension under consideration. Alternatively, if dealing with a total of four dimensions, the binning will involve decomposing the space into hexahedra based on the three dimensions not under consideration. After step 440, the process passes to step 450. See *Paragraph [00175]*.

In step 450, the process determines the point in each of the formed bins with the greatest value in the dimension under consideration. For example, with reference to graph 2, this point with the greatest value would be the points 403, as shown in *Figure 10*. That is, in step 450, the process determines the points 403. After step 450, the process passes to step 460. See *Paragraph [00176]*.

In step 460, the process of *Figures 10 and 11* compares the maximum point in each bin to the other points in the data set, i.e., including those points in other bins, so as to determine some dominated points in the data set. As shown in *Figure 10*, the filled diamonds (403) are

maximum values within a bin along the dimension under consideration. In *Figure 10*, points not dominated by the bin-maximum points are shown as open circles. Further, dominated points are shown as "dots." The "dots" are not greater than the respective points 403 in both dimension 1 or dimension 2. Accordingly, the dots are dominated points, which by definition can not be a part of the Pareto front. As a result, in step 465, the process permanently removes all the dominated points found in the current iteration from further consideration. Thus, it is necessary to compare fewer and fewer points to each other as the process progresses. This drastically improves the computational performance in the later stages of the processing. See *Paragraph [00177]*.

After step 465 of *Figure 11*, the process passes to step 470. In step 470, the process determines whether there are dimensions that have not been "under consideration." If yes, then the process passes to step 475. In step 475, the process proceeds to the next dimension to be the "dimension under consideration." For example, the process proceeds to consider dimension 2, as shown in graph 3 of *Figure 10*. See *Paragraph [00178]*.

After step 475, the process returns to step 440. Thereafter, the process proceeds as described above, i.e., in processing of the further dimension. As the process proceeds through the dimensions, i.e., by making in turn each dimension the dimension under consideration, the number of points in the data set is progressively reduced. See *Paragraph [00179]*.

As described herein, a first dimension will be the dimension under consideration, and thereafter, a second dimension will be the dimension under consideration, for example. It should be understood that during processing with the "second dimension under consideration", for example, the first dimension (which was previously under consideration) is treated as any other dimension, i.e., the first dimension is not, at the time, under consideration. Likewise, when a third dimension is under consideration, the first and third dimension will be treated as any other. See *Paragraph [00180]*.

At some point in the process of *Figure 11*, each dimension will have been considered. Accordingly, at that time, the process will determine, in step 470, that each dimension has indeed been considered. The process then passes to step 480. See *Paragraph [00181]*.

In step 480, the process performs a final dominance check on the remaining points. This final dominance check may be performed using known techniques. The set of remaining points subjected to the final dominance check will be in most cases substantially reduced, as compared

to the number of points in the initial data set. After step 480, the process passes to step 490. In step 490, the fast dominance filtering process ends. See *Paragraph [00182]*.

As shown in *Figure 10* and discussed above, the dimensions (other than the dimension under consideration) are respectively split into some number of bins. The particular number of bins may be based on any of a variety of criteria, such as the number of points remaining to classify, for example, or any other criteria. For example, as shown in *Figure 10*, the bins based on dimension 2 (Graph 2) are courser than the bins based on dimension 1 (Graph 3). For example, as the number of points decreases, the coarseness of the bins may decrease. See *Paragraph [00183]*.

In accordance with embodiments of the invention, the dominance filter provides a speedup. The magnitude of the speedup provided by the fast dominance filter varies of course based on the nature of the binning method, including the size of the bins, and the distribution of the initial set, for example. If the number of points dominated by the maximum points within the bins early in the process is a relatively large fraction of M, , very good speedups are possible in the dominance filtering. The maximum speedups therefore arise when the raw data are relatively evenly distributed throughout the objectives space. See *Paragraph [00184]*.

Hereinafter, further aspects and subtitles of the dominance filtering process are described. The dominance filtering process 400 as described herein assumes that there is no uncertainty associated with the value of each portfolio on each dimension. While this assumption produces quite reasonable and usable results, it is assuredly false. Any metric that purports to measure the future value of a portfolio has some uncertainty associated with the prediction. See *Paragraph [00185]*.

To take that uncertainty into account for the dominance filtering, one needs only to extend the definition of dominance described above. That is, the definition of dominance may be extended to: Given an n-dimensional measurable space whose elements can be partially ordered, and some estimate of uncertainty, ε_i, a vector in this space $x = (x_1, x_2, \ldots, x_n)$ is considered non-dominated if there exists no other vector z such that:

$x_i + \varepsilon_i \leq z_i$ for all i, and $x_k + \varepsilon_k < z_k$ for at least one $1 \leq k \leq n$.

As used in this relationship, the symbol ≤ may be interpreted as "the right-hand-side of the relationship "is better than" its left-hand-side" (or "better-than" relation) without loss of generality. Using this definition of dominance, the dominance filtering process can take the

uncertainty inherent in estimating future values into account. Note that the value of ε need not be the same for each dimension. See *Paragraph [00186]*.

Independent Claim 1 is directed to a method for multi-objective portfolio analysis using dominance filtering, the method comprising:

(a) generating a first set of solutions of portfolio allocations in a portfolio configuration space using a computing device, the portfolio configuration space having a plurality of dimensions;

(b) generating a second set of solutions in a portfolio performance space, the portfolio performance space having at least three dimensions; each solution in the first set of solutions matching with a corresponding solution in the second set of solutions;

(c) selecting a first dimension from the at least three dimensions of the portfolio performance space;

(d) generating bins for all remaining non-selected dimensions of the portfolio performance space;

(e) determining a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension;

(f) comparing the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and

(g) removing the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, the reduced set of solutions being used in investment decisions. *See Figures 10 and 11; Paragraphs [00171]-[00186].*

Independent Claim 19 is directed to a system for multi-objective portfolio analysis using dominance filtering, the system comprising:

a population generation portion that generates a first set of solutions of portfolio allocations in a portfolio configuration space having a plurality of dimensions, and a second set of solutions in a portfolio performance space having at least three dimensions, each solution in the first set of solutions matching with a corresponding solution in the second set of solutions;
a dominance filtering portion that selects a first dimension from the at least three dimensions of the portfolio performance space; generates bins for all remaining non-selected dimensions of the portfolio performance space; determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; compares the solution with the maximum

value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and removes the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, the reduced set of solutions being used in investment decisions. *See Figures 10 and 11; Paragraphs [00171]-[00186].*

VI. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL

1. Whether Claims 1, 2, 6, 7, 11-13, 16-20 and 22-24 are unpatentable under 35 U.S.C. §103(a) over Josephson et al. (U.S. Patent No. 7,155,423, hereinafter "Josephson") in view of Carey et al. (U.S. Patent No. 7,206,760, hereinafter "Carey").

VII. ARGUMENT

1. Rejection of Claims 1, 2, 6, 7, 11-13, 16-20 and 22-24 under 35 U.S.C. 103(a) over Josephson in view of Carey

Independent Claim 1 specifies, *inter alia*, the steps of:

(d) generating bins for all remaining non-selected dimensions of the portfolio performance space;

(e) determining a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; and

(f) comparing the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions.

Independent Claim 19 specifies, *inter alia*, a system for multi-objective portfolio analysis using dominance filtering comprising:

a dominance filtering portion that selects a first dimension from the at least three dimensions of the portfolio performance space; generates bins for all remaining non-selected dimensions of the portfolio performance space; determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; compares the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and removes the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, the reduced set of solutions being used in investment decisions.

Support for these novel aspects of a fast dominance filter of the claimed invention can be found, for example, in *Paragraphs [00171]-[00186]* and *Figures 10 and 11*.

By contrast, Josephson teaches a "classical" dominance filter that removes dominated candidates such that surviving candidates are Pareto optimal. See *col. 4, lines 36-44*.

On *Page 3* of the final Office action, the Examiner asserts that:

> "Josephson teaches:
>
> - c) selecting a first dimension from the at least three dimensions of the portfolio performance space;

- d) generating bins for all remaining non-selected dimensions of the portfolio performance space

- e) determining a solution in each bin of the non-selected dimensions with maximum value along the selected dimension;

- f) comparing the solution with the maximum value in each bine to other solutions in each bin to determine whether other solutions are dominant solutions or dominated solutions; and

- g) removing the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions."

Contrary to the Examiner, Appellant asserts that Josephson does not teach or suggest the particular mechanics of a dominance filter, and in particular, there is no mention in Josephson of the mechanics of a fast dominance filter recited in at least steps (d)-(f) of Claim 1. In addition, it is noted by Appellant that the Examiner does not provide any citation where Josephson teaches the steps (c)-(g) of the claimed invention.

Carey is directed to a method for selecting securities for a portfolio and adds nothing to overcome these shortcomings in Josephson.

For at least this reason, the Examiner fails to establish a *prima facie* case of obviousness because the applied art fails to teach or suggest all the claim limitations of Claim 1, so the rejection of Claim 1 is unsupported by the art and should be reversed. Claims 2, 6, 7, 11-13 and 16-18, which depend from Claim 1, are likewise allowable over the applied art, taken singly or in combination, so the rejection of Claims 2, 6, 7, 11-13 and 16-18 is unsupported by the art and should be reversed.

Similarly, it is respectfully submitted that there is no mention in the applied art of at least the feature of a dominance filtering portion that:

selects a first dimension from the at least three dimensions of the portfolio performance space,

generates bins for all remaining non-selected dimensions of the portfolio performance space,

determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension,

compares the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions, and

removes the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, as recited in independent Claim 19.

For at least this reason, the Examiner fails to establish a *prima facie* case of obviousness because the applied art fails to teach or suggest all the claim limitations of Claim 19, so the rejection of Claim 19 is unsupported by the art and should be reversed. Claims 20 and 22-24, which depend from Claim 19, are likewise allowable over the applied art, taken singly or in combination, so the rejection of Claims 20 and 22-24 is unsupported by the art and should be reversed.

In view of the foregoing, Appellant respectfully submits that the application is in condition for allowance. Favorable consideration and prompt allowance of the application is earnestly solicited.

Dated: April 27, 2009

Respectfully submitted,

By /Peter J. Rashid/

Peter J. Rashid, Reg. No. 39464

VIII. CLAIMS APPENDIX

1. A method for multi-objective portfolio analysis using dominance filtering, the method comprising:

(a) generating a first set of solutions of portfolio allocations in a portfolio configuration space using a computing device, the portfolio configuration space having a plurality of dimensions;

(b) generating a second set of solutions in a portfolio performance space, the portfolio performance space having at least three dimensions; each solution in the first set of solutions matching with a corresponding solution in the second set of solutions;

(c) selecting a first dimension from the at least three dimensions of the portfolio performance space;

(d) generating bins for all remaining non-selected dimensions of the portfolio performance space;

(e) determining a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension;

(f) comparing the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and

(g) removing the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, the reduced set of solutions being used in investment decisions.

2. The method of claim 1, the method further including the step of repeating steps (c) – (g) for at least a second dimension of the portfolio performance space after the dominated solutions are removed from the portfolio performance space.

6. The method of claim 1, wherein the plurality of dimensions is n-dimensions, and the bins are in the form of n-1 dimensional polyhedra in the portfolio performance space.

7. The method of claim 1 further including the step of performing a final dominance check on the reduced set of solutions.

11. The method of claim 1, wherein the investment decisions are based on competing objectives that include risk and return.

12. The method of claim 1, further including the step of repeating steps (c) – (g) for all remaining dimensions of the portfolio performance space after the dominated points are removed from the portfolio performance space.

13. The method of claim 12, wherein a coarseness of the bins is decreased as remaining dimensions of the portfolio performance space are selected.

16. The method of claim 7, wherein the step of performing the final dominance check on the reduced set of solutions includes generating an efficient frontier.

17. The method of claim 1, wherein the step of generating [[a]] the first set of solutions of portfolio allocations includes using an evolutionary algorithm.

18. The method of claim 1, wherein the step of comparing the solution with the maximum value in each bin to other solutions in each bin includes using Pareto dominance that includes uncertainties in measuring competing objectives.

19. A system for multi-objective portfolio analysis using dominance filtering, the system comprising:

a population generation portion that generates a first set of solutions of portfolio allocations in a portfolio configuration space having a plurality of dimensions, and a second set of solutions in a portfolio performance space having at least three dimensions, each solution in the first set of solutions matching with a corresponding solution in the second set of solutions;

a dominance filtering portion that selects a first dimension from the at least three dimensions of the portfolio performance space; generates bins for all remaining non-selected dimensions of the portfolio performance space; determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; compares the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and removes the dominated solutions from the portfolio performance space so as to result in a reduced set of solutions, the reduced set of solutions being used in investment decisions.

20. The system of claim 19, wherein the dominance filtering portion, after removing the dominated solutions from the portfolio performance space, selects a second dimension from the at least three dimensions of the portfolio performance space; generates bins for all remaining non-selected dimensions of the portfolio performance space; determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; compares the solution with the maximum value in each bin to other solutions in each bin to determine whether

the other solutions are dominant solutions or dominated solutions; and removes the dominated solutions from the portfolio performance space so as to result in a second reduced set of solutions.

22. The method of claim 19, wherein the plurality of dimensions is n-dimensions, and the bins are in the form of n-1 dimensional polyhedra in the portfolio performance space.

23. The system of claim 20, wherein the dominance filter portion, after removing the dominated solutions from the portfolio performance space, selects each of all the remaining dimensions from the at least three dimensions of the portfolio performance space; generates bins for all remaining non-selected dimensions of the portfolio performance space; determines a solution in each bin of the non-selected dimensions with a maximum value along the selected dimension; compares the solution with the maximum value in each bin to other solutions in each bin to determine whether the other solutions are dominant solutions or dominated solutions; and removes the dominated solutions from the portfolio performance space so as to result in a final reduced set of solutions.

24. The system of claim 23, wherein the dominance filtering portion performs a final dominance check on the final reduced set of solutions.

IX. EVIDENCE APPENDIX

No evidence pursuant to 37 C.F.R. §§ 1.130, 1.131, or 1.132 is/are entered by the Examiner. Accordingly, no evidence is/are relied upon by the Appellant in this paper.

X. RELATED PROCEEDINGS APPENDIX

No related proceedings pursuant to 37 C.F.R. § 41.37(c)(1)(ii) is/are entered by, relied upon, or submitted by the Appellant with this paper.